CHAPTER 11
PRECISION AND SPECIALTY GROUTING

11-1. General Statement. Precision grouting may be defined as the placement of a special type of grout in a well-defined area under a highly controlled application to meet rigid job requirements. Specialty grouting may be defined as those applications that deviate from conventional techniques. Precision and specialty grouting operations require careful selection of grout mixtures and thorough planning. The most experienced grouting personnel should be assigned such grouting tasks.

11-2. Scope. Grouting can be used in a variety of unique situations. Precision and specialty grouting may require only small amounts of grout, but the outcome may be very significant.

a. This chapter is applicable in part to concrete structures; consequently, grouting techniques, mixtures, materials, and equipment normally utilized for concrete repair can be used on these structures. EM 1110-2-2002 is a comprehensive manual covering many different types of materials, equipment, and repair techniques. This manual not only discusses the use of portland cement grouts, but also concrete, asphalt, shotcrete, drypack, preplaced aggregate concrete, epoxy resins, protective surface coatings, and joint sealers used in repair work. The manual also contains discussion of crack repair, major repairs, and surface repairs.

b. Civil projects that may include grouting as a part of original construction or for repair include highways, surfaces and underground powerhouses, large buildings, and flood control structures. Grouting may be required for repairing and/or strengthening any of the structures listed as a method of satisfying immediate and long-range project needs.

11-3. Applications.

a. Tendon Grouting. The purposes of this type of precision grouting are to provide protection to the steel tendons as well as to provide good bond between the tendons and the ducts, thereby improving the durability and load-carrying capacity of the structural member. Mixtures used in tendon grouting should contain materials that provide protection of tendons from corrosion and are virtually free of components such as chlorides and sulfides that promote stress corrosion of tensioned steel tendons. The mixture should exhibit little or no bleeding and should be shrinkage compensating. The mixture should be easily pumped and free of fine aggregate to ensure maximum penetration into small spaces between tendon strands. The grout should have prolonged pumpability time to provide for recirculation during injection. Admixtures should be used that contain water-reducing agents, controlled expansion additives, and dispersant agents and that produce a grout that is thixotropic for a limited time, shrinkage compensating, dense, and high in strength development when added to portland cement mixtures. Mixtures used for injection into tendon ducts should have high fluidity. Mixing equipment preferably should be of the continuous colloidal or high speed shearing type, and the positive displacement, nonpulsating type of pump should be used for injection.

b. Machine Base Grouting. Civil projects sometimes include the grouting of extremely large steel plates that form the bearing base plates for generators, turbines, roller mills, compressors, rails, column plates, and a variety of production-type heavy machinery. The machine base plates are usually positioned over concrete foundations and fixed by anchor bolts. Shims are used to level base plates, usually leaving 1 to 3 inches between the plate and concrete foundation to be grouted. The space is formed on all sides to contain the grout, which is either poured or pumped beneath the plate from one side only to minimize possible entrapment of air. The grout placement is best accomplished in one continuous operation. The selection of mixtures for use under machine bases and similar placements is described in CRD-C 621 (app A). For very high strength grouts, additives such as silica fume may be considered after appropriate laboratory testing.

c. Rock Bolt Grouting. There are many types of rock bolt anchoring systems. EM 1110-1-2907 includes information on how to install and grout rock bolts.

d. Slab Stabilization. Slab stabilization is a method that utilizes grout to fill voids beneath concrete slabs to minimize impact loading damage, correct faulty drainage, and prevent pumping at transverse joints and contraction cracks. A variety of grout mixtures and mud-cement slurries are used to accomplish this. The WES publication, "Maintenance and Repair Practices for Pavements, Facilities Engineer," contains useful and detailed information on slab stabilization.

(1) Grout mixtures composed of finely graded, clean sand and cement, with admixtures if needed, provide long-term stability beneath slabs, and have recently been replacing mud-cement slurries.

(2) Mud-cement slurries tend to develop very little strength and can shrink, and prove to be unstable in wet conditions. Slab stabilization is usually conducted while old slabs are being prepared for resurfacing. Major items of equipment required are a core drill; a concrete or pug-type mortar mixer; a positive displacement, nonpulsating type grout pump; and associated equipment and accessories.

e. Slab Jacking. Slab jacking is actually an extension of slab stabilization; however, the application is somewhat more involved. Slab jacking may be described as a quick and economical method of raising a settled section to a desired elevation by pressure injecting cement grout or mud-cement mixtures under the slabs.

(1) Purpose. The purpose of slab jacking is to (a) improve the riding

qualities of the surface of the pavement, (b) prevent impact loading over the irregularities by fast-moving traffic, (c) correct faulty drainage, (d) prevent pumping at transverse joints, (e) lift or level other structures, and (f) prevent additional settlement.

(2) Mixtures. A grout mixture consisting of a finely graded, clean sand and cement, having approximately 20 percent cement and well-graded, clean, fine sand with about 30 percent or more fines passing the No. 200 sieve, can be easily pumped and will develop adequate strength. The water content of such a mixture must be one to produce a low-viscosity consistency, yet have sufficient viscosity to maintain the sand in suspension. In the case of mixtures composed only of sand, cement, and water, various types of admixtures may be added to the mixture to either accelerate, retard, or expand the grout; however, such additives should be used with extreme care and their effect on the grout studied by testing in the laboratory prior to use in the field.

(3) Equipment. The minimum major items of equipment normally required to conduct a slab jacking operation efficiently are stated in d(2) above.

(4) Application.

(a) Extreme care must be exercised during slab jacking operations to prevent pyramiding of the grout under the slab in the immediate vicinity of the injection hole. The grout should raise the slab slowly and with uniform pressure. To accomplish this, an array of holes must be drilled through the slab in a pattern that will permit the lateral flow of grout to penetrate all areas under the slab, and the jacking rate should be slow enough to permit the grout to fill all existing voids properly and completely. Only general rules can be used in determining the location of holes for grout injection. The operator learns to space holes according to the particular job at hand. Holes generally should not be placed closer than 18 inches to edges or joints. They should be at locations spaced not more than 6 feet on center so that approximately 25 to 30 square feet of slab is raised by pumping any one hole. Excessive pumping in any one location may result in cracking of the slab. A closer spacing arrangement of the holes will be required if the slab cracks. Additional holes may occasionally be required to fill voids that have no communication with each other. The diameter of the holes should be 1-1/4 to 1-1/2 inches.

(b) If the grout is pumped too quickly, the slab may be cracked by pyramiding. A thick slurry grout should be used initially for slab lifting. A thick grout should not be pumped at rates exceeding 1 cubic foot per minute. The pumping rate for low viscosity and thin grouts may be increased to as much as 3 cubic feet per minute.

(c) When jacking is done from one hole, the grout injection should continue until the grout appears in adjacent holes or the slab is raised to the proper grade. Adjacent holes may temporarily be sealed with wooden plugs, which can readily be removed following the setting of the grout. When the grout nozzle is removed following the completion of slab jacking operations, all holes should be cleaned and filled with a stiff 1:3 cement-to-sand mortar mixture, which is tamped into place and floated to a smooth finish.

(d) Application of the slab jacking method must be carried out by competent, experienced crews. A slab-jacking crew generally consists of from 6 to 10 people.

f. Lost Circulation Grouting. During the drilling of boreholes, drilling fluid circulation may be lost to a highly fractured zone or a weak or porous formation. In the event of lost circulation, materials may be added to basic portland cement grout mixtures to block, bridge, or seal the openings in the formation. The lost circulation materials most commonly used include sands of various types and gradations, cellophane flakes of controlled sizes, ground plastic, shredded rubber, and crushed cottonseed hulls. These materials may be added to the cement slurry individually or in combinations; the latter rarely exceeds two materials.

g. Preplaced Aggregate Grouting. Preplaced aggregate grouting involves the placement of a selected type and gradation of a coarse aggregate in forms or cavities and the injection of a sanded or unsanded portland cement grout into the mass to fill the voids. This method is sometimes used for constructing "cast in place" piles, and for providing roof support for abandoned mines. Useful information in planning preplaced aggregate grouting is discussed in WES Technical Memorandum 6-380.

h. Postplaced Aggregate Grouting. The placement of grout into forms or cavities prior to the placement of the aggregate is a quick and economical application. The grout mixtures can also be proportioned with a lower water content since pumping into injection pipes is not necessary. The grout is initially introduced into the placement area and is followed by the placement of the aggregate by clamshell, end loader, or other means. Maintaining a grout level above aggregate placement is important at all times except when "topping off" nears. Means should be provided to finish and cure the surface.

i. Foam Slurry Grouting. The constituents that compose foam slurries and a range of physical properties are briefly described in paragraph 5-2c. Mixing and pumping systems generally consist of in-line metering foam generators or transit mix trucks, tub mixers, and ribbon blenders. A measured amount of foam is introduced into a measured amount of cement slurry for homogeneous mixing. The advancing cavitation-type pump is best suited for pumping foam grout. Injection lines four or five inches in diameter have been found to be satisfactory for the placement of foamed slurry grouts.

j. Saltwater Grouting. Saltwater grouting is conducted during the sinking and driving of shafts and tunnels in salt formations and behind borehole casings that either terminate in cavities excavated into salt domes, or pass through salt formations for various purposes. Grouts developed for possible use in waste isolation in salt formations require extensive developmental work in providing a grout having a durability of extremely long life. The grout mixture used should contain approximately 3 pounds of soduim chloride (NaCl) in solution per gallon of mixture water to provide a brined, saturated mixture water that will prevent dissolution of rock salt and contact faces. Amounts of salt in excess of approximately 3 pounds per gallon tend to retard portland cement mixtures, whereas amounts less than 3 pounds per gallon may result in a degree of acceleration of the set. Salt-saturated mixture water should also be considered in grouts proposed for use in saline environments. Attapulgite clay is used in lieu of bentonite in salt grouts.

k. High-Density Grout Placements. Structures constructed for nuclear and high-energy laser research and hazardous waste storage frequently require high-density walls, ceilings, and floors. Such construction may be accomplished by using the preplaced aggregate method; magnetite or ilmenite coarse and fine aggregates or other types of high-density aggregates are substituted for the conventional types of aggregates normally used. Particular attention must be given to forming, which must be designed to support heavy loads and to be essentially watertight.

l. Grouting Waste Disposal Wells. Extremely high durability grouts should be developed for use in plugging hazardous waste disposal wells. This application requires portland cement grouts that are expansive, impermeable, and highly resistant to chemical attack. A waste disposal well may be plugged with grout by means of conventional oil well cementing equipment or similar grouting systems. The grout may be placed in a single stage or a number of stages through the use of the drill stem and the draw-works of the drill rig. A variety of downhole tools are available for such operations. Extensive quality assurance is needed in this type of application.

m. Pile Jacketing. Bridge and causeway pilings frequently suffer extensive deterioration as a result of water erosion, scouring, and marine infestation and growth. An economical and expedient method of repairing these pilings is encasement of the pilings in a protective jacket of grout. The jackets normally consist of baglike nylon forms placed around steel reinforcing mesh that has been attached to the damaged area of the steel, concrete, or wooden piling to be jacketed. The nylon form is then filled with the grout. The grout mixture is normally proportioned using a sand filler and a grout fluidifier and may contain Type III high early-strength cement when conditions may require early setting and strength development. This application, using conventional portland cement grouting equipment, may be made both under and above water.

n. Grouting for Powerhouses and Deep-Buried Structures. Powerhouses, both above and below the surface, and deep-buried structures may require grouting. Void areas in the surrounding soil or rock adjacent to powerhouses or deep-buried structures can be grouted with well-designed grout mixtures to further enhance the stability and durability of the structures.

o. Riprap Grouting. The stabilization of riprap placements may be improved by grouting the unconsolidated riprap. Riprap grouting may be accomplished above and below water in providing slope protection for revetments, shoreline stabilization, levee facing, and similar projects. Riprap grouting applications normally consist of the gravity or pump placement of fluid sanded-cement grouts into the voids existing in riprap. The mixtures may contain up to 3 to 4 parts of sand by weight of the cement. For the steeper slopes, more viscous grout is required. The grout is usually filled to approximately 1/2 to 3/4 of the depth of the voids and, where possible, topped out by brooming and cured by conventional methods.